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XXIII.—*The Process of Fecundation in the Vegetable Kingdom, and its relation to that in the Animal Kingdom.* By Dr. L. Radlkofer*.

Sect. I. *The Regular Propagation of Plants, and the Organs devoted to it.*

After the existence of different organs, whose *cooperation* for the production of the rudiment of a new vegetable individual appeared to be a *necessary* condition, had been demonstrated in one series of the plants long regarded as Asexual—the Cryptogamia of Linnæus,—it was natural that the question should press itself upon the minds of naturalists, whether or not a *sexual* process of propagation was not connected with the *maintenance of the species*, in *all* departments of the Vegetable Kingdom, either occurring by itself, or in company with other contrivances for attaining a similar end,—I mean the multiplication of plants by division and gemmation, through the individualization of cells or groups of cells.

Many who had entertained the question had also arrived at the conviction that it must be answered in the *affirmative*; and they were not behindhand even in finding out the required sexual organs in the said plants. But their efforts served for the most part only to verify the words with which Montagne commences the account of his observations on the multiplication of the Characeæ: "The sciences of observation, and natural history in particular, present in their study this remarkable circumstance, that we scarcely ever arrive, at the first onset, at the aim which we propose to attain†." Now, however, reliable ob-

* Leipsic, 1857, 8vo. Translated by Arthur Henfrey, F.R.S. &c.

† Ann. des Sc. nat. 3 sér. xviii. p. 65.

servations have in many cases confirmed the earlier conjectures; not in all groups of plants, however, have they demonstrated the existence of sexes. This applies to the Fungi and Lichens in particular. We shall endeavour in the following pages to expound the results of these observations in systematic order, making reference at the same time to the opinions of the older writers.

1. Fungi.

Micheli had already discovered those organs, terming them sometimes 'filamenta' and sometimes 'stemones,' which Gleditsch, Bulliard, and some later observers regarded as homologous with the stamens of the higher plants. Micheli* himself had ascribed to them the office of keeping apart the 'lamellæ' of the Agarici, so as to prevent the seeds decaying between them.

These organs, which have been observed in various Hymenomycetes, are cylindrical tubular cells, standing on the hymenium itself between the basidia and the paraphyses, and containing colourless granular fluid. The granules display molecular motion.

According to Montagne†, their contents are ultimately discharged, and appear at the points of the cells in little round drops. He ascribes to the stickiness of this liquid the adhesion of the spores detached from basidia, to their cells, without decidedly adopting the opinion of Corda, that the spores are thereby fecundated. Corda‡ regarded these 'granule-bearing utricles,' from the analogy of their structure and contents, as organs representing anthers, 'antheridia.' In the third volume of his 'Icones Fungorum§,' he altered his opinion, and thought it better to compare these organs rather with the simple pollen-cell than with the elaborately constructed anthers; hence he gave them the name of 'pollinaria.' He assures us that their appearance is anterior to the development of the basidia, that the spores are not formed until the period when the pollinaria begin to discharge their contents, and that the latter disappear soon after,

* P. A. Michelius, Nova Plant. Genera juxta Tournefortii methodum disposita. Florent. 1729, pp. 126, 133. tab. 68. L, 73. I. K. L, 76. A. B. See also Hedwig, Theoria Generat. et Fructificat. Plantar. Cryptogam. Linnæi. Petropol. 1784, p. 130.

† C. Montagne, Organography and Physiology of the Class Fungi. Transl. by the Rev. M. J. Berkeley, Ann. Nat. Hist. vol. ix.

‡ A. J. Corda, Ueber Micheli's Antheren der Fleischpilze. Flora, 1834, i. p. 113; Icones Fungor. tom. ii. p. 35. tab. 15. fig. 124. 4. *g.* (Prague, 1838.)

§ Ic. Fung. t. iii. p. 44 *et seq.* (Prague, 1839.)

at the time when the spores are ripe. Klotzsch* calls them anthers, and believes that he has observed that the spores which come in contact with these utricles are more certain to germinate. The majority of recent inquirers regard these structures as forms representing stages of development of the basidia†. Berkeley‡ calls them 'utricles.' Leveillé§ gives them the name of 'cystidia.' We shall immediately examine his view of their import.

In his "Disposition méthodique des espèces du genre *Erysiphe*‖," the last-named *savan* expresses the opinion that the *cystidia* of other Fungi are represented by the cells which rise from the mycelium in longitudinal rows, as jointed filaments (*spores articulées*, Lev.; *filaments sporifères* (*Oidium*), Bornet) supported on branches of the mycelium (*pedicellis*), and which, from separating readily, like the cells of *Oidium*, fall on the mycelium, and give this a pulverulent aspect. He conjectures that these cells are destined to fecundate the subsequently developed *conceptacula* (*peridia*)¶. Although far from regarding the granules of the contents of these cells, which likewise exhibit molecular motion, as spermatozoids, yet he sees, in the relative time and order of development of these and the conceptacles, and the circumstance that enduring rain, which washes these cells from the mycelium, or continued heat, which dries them up, produces barrenness of these Fungi,—sufficient ground to support his conjecture. The words with which he concludes his exposition appear to me so characteristic of the present state of the question, and the mode in which it is usually treated, that I cannot refrain from quoting them here**:—

"The Fungi have been considered as asexual plants, and there is really no proof that they have sexual organs. But it is not long since the Algæ were also regarded as asexual plants. The beautiful researches of MM. Decaisne and Thuret have taught us that these plants are not only furnished with male and female

* Dietrich's Flora der Konigreich. Preussen, Band vi. (Vide Schleiden, Grundzüge der wiss. Botanik, 3rd edit. ii. p. 40.) (Principles of Botany (London), p. 156.)

† *Vide* Tulasne, Ann. des Sc. nat. 3 sér. xx. p. 173, note 2 (1853).

‡ Berkeley, on the Fructification of the Pileate and Clavate Tribes of Hymenomycetous Fungi. Annals of Nat. Hist. i. p. 81 *et seq.*

§ Leveillé, Recherches sur l'Hymenium des Champignons. Ann. des Sc. nat. 2 sér. viii. pp. 325, 326 *et seq.* (1837).

‖ Ann. des Sc. nat. 3 sér. xv. p. 109 (1851).

¶ Lindley, Berkeley, Fresenius, Amici and Tulasne have seen these cells germinate, and regard them as brood-cells. Tulasne, Quædam de *Erysiphis* animadversiones. Bot. Zeit. 1853, p. 259–60. [Also Nouv. Obs. sur l'*Erysiphe*. Ann. des Sc. nat. 4 sér. vi. p. 299 (1856).—A. H.]

** *Loc. cit.* p. 119.

organs, like the Characeæ, Mosses, and Hepaticæ, but that they are also monœcious and diœcious. How is it, then, that we find nothing of the same kind in the Fungi? Perhaps, as was long the case with the Ferns and Equisetaceæ, the organs are sought where they do not lie. The cystidia of the Basidiosporous Fungi, the paraphyses of the Thecasporous Fungi and of the Lichens, and the free utricles of the mycelium of the *Erysiphes,* seem to me to represent organs of fecundation. Although their presence is not constant, we cannot refuse them a destination. No one has hitherto thought of attributing to them any part in the nutrition, respiration, or circulation; and it does not require any great effort of imagination to suppose that they serve for reproduction: what is difficult, is to prove this. But ought we to conclude from the fact, that these organs do not exist in all Fungi, that they do not fulfil any function, and that they are useless in those cases where they are observed? No; we must wait until experience has spoken. In the research of truth, we have first to prove that existing theories are false, and then to show by direct experiment the reality and the advantages of that which is proposed: this, however, is impossible for me at present. With the aid of the simplest preparation, I doubt not, the existence of fecundating organs will be established; but it must not be forgotten that the principle vivifying the germs is not always accompanied by spermatozoids, as is shown us by the Phanerogamia. Why should not this be the case also in other plants? In seeking and recognizing as the incontestable character of the existence of male organs, these moving corpuscles, do we not seek that which cannot be found? This great exception of the Phanerogamia is well worthy to fix the attention of investigators of nature."

To render the historical summary complete, we have still to mention that which, in Hedwig's eyes, above all spoke decisively against their supposed nature, namely that the 'stamina' of Micheli remain equally fresh during the maturation of the spores, which in his opinion must always be subsequent to the fecundation. From observations on species of *Agaricus, Hydnum* and *Boletus,* resting upon the epoch of their development, and its non-coincidence with that of the formation of the spores, he considered "the very numerous, oval, light brownish globules lying on the filaments on the inner surface of the volva, annulus, and the surface of the stipe itself," as the male fecundating apparatus. *Agaricus* and *Boletus* are, in his view, monœcious plants with distinct sexes*. Similar conditions as regards the

* J. Hedwig, Theoria Generat. et Fruct. Plantar. Cryptogam. Linnæi. Petrop. 1784, pp. 132, 134 *et seq.*

order of their appearance led Meyen* to the opinion "that the *Æcidiolum exanthematum*, Ung., is the male or fecundating structure of the *Æcidium*-pustule containing true spore-like vesicles, by which it is succeeded." At the same time, Meyen was "by no means of opinion that an actual or true fecundation took place here." The same contradiction occurs in his expressions relating to the Fungus-anthers of the older authors (*cystidia*, Lev.), which he held to be "organs which contain a fertilizing substance," and a few lines further on, "abnormally altered sporophores†" (basidia).

The investigations of Tulasne, which are in close connexion with the researches of Itzigsohn on the Lichens, presently to be mentioned, are partly supplementary to those above enumerated, and partly of a nature to open out new points of view for the study of the organs of fructification of the Fungi. For the sake of rendering these matters perfectly clear, I postpone the details to the section on the Lichens, and only mention here, that Tulasne found in the Fungi, and in the first instance in the Pyrenomycetes‡, corpuscles similar to Itzigsohn's spermatozoids of Lichens. He calls them *spermatia*, and the structures in which they are contained, *spermogonia*. The latter are found sometimes on the same thallus with the thecæ filled with spores, sometimes separated from these, and have frequently been regarded as distinct and independent Fungi (species of *Sphæria*, *Cytispora*, *Microspora*, *Polystigma*, *Ascochyta*, &c.). And he considers several genera of the Coniomycetes, in like manner, to be dependent and imperfect structures, and thinks that they represent, as for example *Æcidiolum exanthematum*, Ung., spermogonia of Uredineæ or Sphærieæ, &c.§

Besides these spermatia and the spores contained in the thecæ, the same inquirer found, in some cases in the same Fungi, other spore-like bodies, which, like the spores of the Hymenomycetes, were developed upon sterigma-like processes, each upon a basidium-like cell, and these he therefore calls *stylospores*. Concerning the order in which these various stages of development of the Fungi, bearing spermatia, stylospores, or proper spores, make their appearance, he observes, that the spermatia, which may be contemporaneous with the stylospores, always appear

* F. J. F. Meyen, Pflanzenpathologie, herausgeg. v. Nees v. Esenbeck. Berlin, 1841, p. 143.

† Wiegmann's Archiv, 5 Jahrg. Bd. ii. Berlin, 1839, p. 50.

‡ L. R. Tulasne, Note sur l'Appareil reproducteur dans les Lichens et les Champignons. Ann. des Sc. nat. 3 sér. xv. p. 370. [Transl. in Ann. Nat. Hist. viii. p. 114.]

§ See on this point Tulasne, Seconde Mémoire sur les Uredinées et les Ustilaginées. Ann. des Sc. nat. 4 sér. ii. p. 113 *et seq.* (1854).

before the perfect form, sometimes even several months earlier, "like the antheridia of the Ferns or Equisetaceæ before the formation of the spore-bearing capsules of these plants."

The occurrence of spermatia is not limited to the sections of the Fungi above mentioned. In the Discomycetes, also, Tulasne found them (as in *Cenangium, Tympanis, Dermatea, Peziza, Stictis, Tryblidium, Rhytisma, Hysterium, Heterosphæria, Bulgaria*), and in part upon the same organs which bore the sporiferous asci, preceding the formation of these (*Cenangium Franguláe*, Tul.), or about simultaneous with them (*Peziza benesuada*, Tul.), "perhaps representing hermaphrodite receptacles*."

The like are met with in the Hymenomycetes (Tremellini)†. They have here two kinds of origin. In some (*Tremella mesenterica*, Retz.) they originate side by side with the basidia, at the ends of the hymenial filaments imbedded in the gelatinous mass; in others (*Dacrymyces deliquescens*, Dub., &c.) they are developed from the multilocular spores, each cell (each chamber) producing a pedicel, the end of which swells up into a globe, which subsequently separates as a spermatium. Another portion of the same spores exhibits the ordinary kind of germination—if, for the sake of convenience, this expression may be permitted,—such as is known of the spores of Fungi from the researches of Oschatz‡, Corda§, Tulasne||, Bornet¶, Cohn**, De Bary††, &c.: the cells of the spores extend out at one or more points into filiform prolongations, the threads of the mycelium. These spores exhibiting such diverse development, although they appear exactly alike to our eyes, are compared by Tulasne to the two kinds of spores in the Lycopodiaceæ and Rhizocarpeæ; and he regards it as fitting to apply to them the terms 'androspore' and 'gynospore,' which Bayrhoffer, without equal ground, had introduced for the Lichens. The latter kind of formation of spermatia

* Tulasne, Recherches sur l'Appareil reproducteur des Champignons. Ann. des Sc. nat. 3 sér. xx. p. 129, 1853; De Organis apud Discomycetes propagationi inservientibus. Bot. Zeitung, 1852, p. 49; Nouvelles Recherches sur l'Appareil, &c. Comptes Rendus, Nov. 13, 1852, p. 841. (See also the articles under the heads of the genera cited here, in the 'Micrographic Dictionary.')

† Tulasne, Observ. sur l'Organisation des Tremellinées. Ann. des Sc. nat. 3 sér. xix. p. 193 (1853).

‡ Oschatz, De Phalli impudici Germinatione. Nova Acta A. C. L. C. xix. ii. p. 663.

§ Icones Fungorum.

|| Ann. des Sc. nat. 3 sér. xv. p. 271, &c. *loc. cit.*

¶ Etudes sur l'Organisation des *Meliola*. Ann. des Sc. nat. 3 sér. xvi. p. 264.

** Entwicklungsgeschichte der *Pilobolus crystallinus*. Nova Acta A. C. L. C. xxiii. i. p. 505.

†† Botan. Zeitung, 1854, p. 425.

occurs also in *Peziza bolaris*, Batsch*, *Peziza vesiculosa*, Bull., and *Peziza tuberosa*, Bull.†, modified in the last two by the occurrence, in the place of the simple pedicel between the spermatia and the (andro-) spores, of a complicated structure forming in itself a kind of mycelium—*promycelium*, Tulasne; in *Bulgaria iniquans*, Fries, this occurs together with the former. "It corresponds in every respect to the formation of spermatia in the majority of the Lichens, where they originate singly upon a cell which nourishes them‡."

Of the subsequent history of the spermatia formed in this way, which Tulasne calls *sporogenous*, nothing further is known; on the other hand, a kind of germination has been observed in some of them which are produced, not from the spores, but from the spermogonia, and which Tulasne, in reference to their later evolution, calls *opsigenous*. When left for a long time in water, they develope filiform prolongations, like spores. So also with the spermatia which precede the formation of the ergot, which, with the tissue producing them, were described by authors as a *Sphacelia*§, and those of *Sphæria Laburni*, which hitherto had been regarded as the spores of a *Cytispora* in the vicinity of the perithecia of the former.

In face of these observations, and of the experience that physiologically diverse organs frequently have similar characters, Tulasne naturally did not venture to declare these two kinds of spermatia identical; nor, in the absence of direct observation on their relation to the fructification of the Fungi—not to speak of the opsigenous, which may merely represent a second form of the stylospores,—even to compare the sporogenous spermatia

* Now and then, though rarely, spores are met with which produce at the same time spermatia and one or more mycelial filaments. (Ann. des Sc. nat. 3 sér. xx. p. 174.)

† Of the spermatia of this species, Tulasne observes, "Neither is it uncommon to perceive, in the interior, an incomplete excentric circle, a sort of spiral line, the inner extremity of which would correspond pretty nearly to their centre; but I have never remarked that they were endowed with any movement." (*L. c.* p. 176.)

‡ In the same memoir Tulasne shows, that the pairs of cells (*sporidia bilocularia*) hitherto regarded as spores, in the genus *Podisoma*, are only the basidia, which produce much branched and multicellular sterigmata, and only upon these the proper, subsequently germinating spores; as Gasparrini had already observed. The granules of *Æcidium* and *Uredo*, and the fruits of *Puccinia* and *Phragmidium* behave like these sporidia of *Podisoma* as regards their growth in germination. See Bot. Zeitung, 1853, p. 611; Ann. des Sc. nat. 4 sér. ii. p. 123 (1854).

§ Tulasne, Mémoire sur l'Ergot des Glumacées. Ann. des Sc. nat. 3 sér. xx. p. 5. The ergot itself is shown, by Tulasne's beautiful investigations, to be the sclerotoid mycelium of a Sphæriacea (*Claviceps purpureus*, Tul.), the development of which takes place after the ergot has lain several months in moist earth. (See 'Claviceps,' Micrographic Dictionary.)

definitely with the spermatozoids of the rest of the Cryptogamia.

In like manner, future observations must decide whether these sporogenous spores resemble the proper spores of the Uredineæ in any other respect than that merely relating to their origin*. De Bary† and Caspary‡ have furnished researches, partly confirming Tulasne's, partly adding to them.

In conclusion, one more kind of spore-formation remains to be mentioned, which has its analogy and a wider field of occurrence in the Algæ (Zygnemeæ, Desmidiaceæ, &c.), the so-called *conjugation* in *Sizygites*§. We shall return to this case hereafter, in examining the import of the process of conjugation generally.

2. Lichens.

In the Lichens, Micheli‖ regarded the spores and thecæ as the (female) flowers, the sterile thallus as the male plant, the soredia as the seeds. Dillenius¶ and Linnæus** regarded the apothecia as the male, and the soredia as the female organs of fructification. Hedwig†† gave these parts, according to his observation that the latter preceded the former, exactly the reverse interpretation. He took for their male organs not merely the soredia, but also those structures already known by him and Dillenius, and figured in *Borrera ciliaris*,—distinguished by the former only so far as their external appearance allowed,—the brown or black dotted elevations‡‡, which recently, since Itzigsohn declared them to be antheridia, have so strongly excited the interest of botanists.

Schacht§§, in stating that "Itzigsohn's antheridia were first seen and figured by Alex. v. Humboldt‖‖—(he found them on

* *Vide* note ‡ (p. 247).

† Untersuchung. über Brandpilz. Berlin, 1853.

‡ 'Flora,' 1855, p. 483.

§ *Vide* Ehrenberg, Verhandl. Gesell. Naturf. Freunde. Berlin, B. 1. Stuck. ii. p. 98, 1820; Corda, A. C. J., Prachtflora europaisch. Schimmelbild. Leipz. u. Dresd. 1839, p. 49.

‖ Micheli, Nova Genera Plant. Florent. 1729, pp. 73, 74.

¶ Dillenius, Historia Muscorum. Oxon. 1741.

** Linnæus, Genera Plantarum, ed. 6. Holmiæ, 1764, p. 566.

†† Hedwig, Theoria Generat. et Fructificat. Plant. Cryptog. Linnæi. Petrop. 1784, p. 120 *et seq.*

‡‡ "Puncta quædam aliquid diversum ab ipsa fronde notantia;—verrucas nigro punctulo—brevi in vertice macula fusca, dein nigricante—notatus; hanc verrucam si verticaliter utrinque secaverimus....apparet distinctus sub vertice loculus.....granulosa massa refertus," &c. *l. c.* pp. 121–123.

§§ H. Schacht, Die Pflanzenzelle. Berlin, 1852, p. 120.

‖‖ Alex. ab Humboldt, Flora Friburg. specimen, Plant. Cryptogamas præsert. subterraneas exhibens. Berol. 1793.

Lichen parietinus;—Humboldt explained them as rudiments of apothecia"),—appears to me to err in an explanation of a figure on Plate 2 of the 'Flora Friburgensis' of Humboldt, representing a *varietas prolifera* of *Lichen parietinus*, which the author describes as follows, at page 15: "Peltæ, margine revoluto, cui 6–8 peltæ juniores citrini coloris elegantissime impositæ sunt. Nescio an hæc varietas ullo Botanico jam prius observata fuerit?" On the other hand, Humboldt had of course seen the black spotted elevations on the surface of the thallus of *Borrera ciliaris*, described by Hedwig, but wholly refrained from expressing an opinion of their import; for at the end of the description of *Lichen ciliaris**, he mentions them merely with the words: "Quid verrucæ atræ quibus sæpissime pagina superior frondis vel laciniarum notata apparet?"

Meyer† regarded the organs in question as abortive apothecia, and considered their black colour, in Lichens which normally present no black apothecia, as a peculiar diseased character.

By other Lichenologists they were characterized, sometimes as peculiar species of Lichens (*Pyrenothea*, Fr.‡, *Thrombium*, Wallr.), sometimes as parasites (*Endocarpon athallon*, Spr.; *Sphæria epiblastemica*, Wallr.; *Sphæria lichenicola*, Smf.; *Sphæria Lichenum*, Rebent.); sometimes, when the papillæ were rather larger, as in *Lichen ciliaris*, &c., as 'vesicular-fruit' (*Physcocymatia*, Wallr.), or as a kind of accessory apothecia filled with gongyli (*Cephalodia*, Ach.), or as anamorphoses of apothecia (*status angiocarpi Lichenum gymnocarporum*, Fries§). Holle‖, when he describes among the rudimentary apothecia of *Borrera ciliaris* some of dark brown or blackish colour, the internal tissue of which is partly decayed, and appears like a fluid, in which often swim whole legions of small Fungoid structures,—appears to me also to have confounded the organs of which we are speaking with the young apothecia. Speerschneider describes them in *Borrera ciliaris* and *Parmelia Acetabulum*, as *soredia*¶; in another place as abortive and lignified apothecia**.

H. Itzigsohn†† next made the observation, that the corpuscles

* *Loc. cit.* p. 21.

† G. F. W. Meyer, Die Entwickl., Metamorph. und Fortpflanz. der Flechten. Göttingen, 1825, p. 162 *et seq.*

‡ V. Flotow, indeed, regarded part of the species of this genus as not independent, and called the individuals furnished with them *variet. pyrenodes*.

§ *Vide* Flotow, in a letter to Itzigsohn, Bot. Zeitung, 1850, p. 914, and Tulasne, Ann. des Sc. nat. 3 sér. xvii. p. 153.

‖ G. v. Holle, Zur Entwickl. von *Borrera ciliaris*. Göttingen, 1849, pp. 6 and 7.

¶ Botan. Zeitung, 1853, p. 730; 1854, p. 491 and p. 506. pl. 12. fig. 6.

** *Ibid.* 1854, p. 614. pl. 14. figs. 11 & 12.

†† *Ibid.* 1850, pp. 393, 916 *et seq.*

contained in these organs—described by him as exactly like the spermatozoids of *Polytrichum* and *Marchantia*,—when brought to light by pressure, began after some time to move tumultuously. He therefore held these corpuscles to be the *spermatozoa of the Lichens*, and their conceptacles *antheridia*. He describes the latter in *Cladonia alcicornis* as small (scarcely as large as a millet-seed), mostly stalked nodules at the tips of some of the lobes of the thallus, quite distinguishable by the naked eye, but not occurring in all individuals, on account of the probably diœcious inflorescence;—as larger in *Borrera ciliaris*, in which they are distinguished by their brownish colour from the young apothecia, which are green. The spermatozoa he describes further as little cylinders, whose length exceeds their diameter 10–20 times. They are stated to be developed in lenticular cells which are contained in the gonimic layer, and out of which he had seen them escape. Their movement was essentially different from mere molecular motion (no motive organs, however, are described, at all corresponding to the cilia of the Moss-spermatozoids): the motion was seen most clearly in those spermatozoa which collected at the top of the water as a shining, hard pellicle after several days' maceration of the Lichens, going on to the commencement of putrefaction (*Borrera, Peltidea, Lecanora, Parmelia, Cladonia*).

Kützing* and K. Müller† confirmed the existence of the cylindrical corpuscles, but saw no movement of them. Von Flotow‡ saw it (in *Verrucaria*), but regarded it as molecular motion, and the antheridia as abortive fruits. Rabenhorst, after many unsuccessful attempts§ with macerated Lichens, likewise perceived it, and was of opinion that it was of decided animal, *i. e.* spermatozoic nature‖. Schacht¶, after minute examination, can only recognize in the antheridia "stunted (verkummerte) rudiments of the apothecia," and the spermatozoa of Itzigsohn he regards as "the cells of the articulated paraphyses separated by absorption;" in a subsequent publication**, as "foreign bodies come in through decomposition, probably Vibriones." Hofmeister†† likewise only saw a molecular motion of the said corpuscles: the corpuscles with slow, snake-like motion, which

* Botan. Zeitung, 1850, p. 913.

† In the addition to his translation of Montagne's essay, "Morphologische Grundrisse der Flechten," Halle, 1851, p. 30.

‡ Botan. Zeitung, 1850, p. 916.

§ *Ibid.* 1850, p. 913. ‖ *Ibid.* 1851, p. 153.

¶ Pflanzenzelle, Berlin, 1852, p. 120.

** Schacht, Das Mikroskop. &c., 2nd edit. Berlin, 1855, p. 83.

†† W. Hofmeister, Vergleich. Untersuch. der Keimung, &c., höherer Kryptog. Leipzig, 1851, p. 139, note.

appeared after long maceration of *Borrera* (even of such pieces as bore none of the so-called antheridia), he regarded as Infusoria.

Tulasne* gave a new aspect to Itzigsohn's observations when he demonstrated the existence of his antheridia, not only in the great majority of all Lichens, but also in the Fungi (as above indicated, p. 245), and thus secured new points from whence their nature could be critically examined.

Their regular occurrence on almost all genera of Lichens, the peculiarity of their aspect and structure, would not permit him to regard them as *accidental organs*, as abortive apothecia, parasites, or Lichens *sui generis*, as had been done by previous authors,—but warranted him in the conviction that they were a *special reproductive apparatus, probably occurring in all Lichens*, which, in reference to physiological functions, doubtless stand in close connexion with the other fructifying apparatus, represented by the apothecia. He was prevented from distinctly acknowledging Itzigsohn's spermatozoa, as such, by the want of direct observations on their function. He therefore prefers for the present to attach to them the name '*spermatia*,' which, however, is only intended to express that they are bodies destined to play some part in the reproduction. He calls the organs in which they are contained '*spermogonia*.' The structure of these is the same as in many Fungi (Pyrenomycetes and Discomycetes)—closed receptacles more or less resembling the perithecia of the Pyrenomycetes, usually imbedded in the thallus and projecting only a little from its surface, rarely free above, like the apothecia (*Cladonia, Cetraria, Gyalecta*), of globular or oblong form, with a simple or multilocular cavity, which is clothed by a kind of hymenium; this consists of basidium-like cells or rows of cells (*sterigmata*) resembling Conferva-filaments, at the points and joints of which originate the spermatia, as linear corpuscles, apparently in the same way as the ramification takes place in *Conferva glomerata*†, and by no means in special cells‡. He compares these spermatia with the motionless spermatozoids of the Florideæ, and—on the ground of the unexceptional differences between the form and dimensions of the spermatia on the one

* Tulasne, Note sur l'Appareil reprod. dans les Lichens et les Champignons. Ann. des Sc. nat. 3 sér. xv. p. 370 (translated in Ann. Nat. Hist. 2nd ser. viii. p. 114); Mémoire sur l'Histoire organographique et physiologique des Lichens. Ann. des Sc. nat. 3 sér. xvii. pp. 5 & 153 (1852).

† *Vide* the figures in V. Mohl's 'Vegetable Cell,' plate 1. fig. 1.

‡ Tulasne himself (Ann. des Sc. nat. 3 sér. xvii. p. 216) entertains some mistrust of his own earlier observation, that in *Verrucaria atomaria*, spermatia and fertile sporanges are developed in the same conceptacles (apothecia),—a condition which has an analogy among the Fungi in *Peziza benesuada*, Tul., *Cenangium Frangulæ*, Tul., and the Tremellini.

hand, and of the true spores and gonidia on the other, but, above all, from the consideration of the peculiar mode of development in each of these organs,—he declares distinctly against the opinion which would estimate the spermatia only as spores or gonidia*.

The view of Leveillé†, who regarded the paraphyses of the Lichens as their fecundating organs, and Bayrhoffer's‡, who ascribed a different sexual nature to the separate layers of the thallus, need merely be mentioned for the sake of completing the historical summary.

3. Algæ.

But a few years since, exact science knew nothing of a process of fecundation in the Algæ. The conjugation of *Spirogyra*, known as long ago as by Vaucher§, had indeed been taken to be such; but the asserted observation, that the formation of the spore occasionally occurred without any union of the conjugating cells really having taken place, had brought the whole matter into question again in the most recent time. Vaucher had perceived the so-called horns, and even conjectured that they had the import of anthers||; but from the suspicion to the experimental proof, with which alone science can be satisfied, the road is often very long, and not to be traversed without numerous fruitless diversions.

* Tulasne's observations extend at the same time to the (so-called) germination of the spores of Lichens, and confirm and complete in this respect the statement of Meyer (*loc. cit.* p. 175), Fries (Lichenogr. Europ. reformat. Lund, 1831, pp. lv, lvi), Buhse (Ueber d. Fruchtkörper der Flechten, Bull. Naturforsch. Gesell. Moskau, Bd. 49, p. 32, 1846), Meissner (Bot. Zeitung, 1848, p. 90), Holle (*l. c.* p. 31), and Speerschneider (Bot. Zeit. 1853, p. 721, 1854, pl. 14. figs. 10 & 11). The internal cell of the spore breaks through the cuticle—in the compound spores usually at the points of the end-cells, and elongates into ramified filaments. Subsequently septa appear in these, from their point of origin onwards, by which they are converted into moniliform rows of cells. By interweaving together, these filaments form a tolerably closely-meshed plexus—*protothallus* of authors, *prothallus* of Tulasne,—on which, at several points, is formed a layer of colourless, round cells—to judge from fig. 3. pl. 3 of Tulasne's memoir, by detachment of cells produced as buds (*abschnürung*) —as is assumed of the gonidial cells by Schacht (Pflanzenzelle, p. 135) and Speerschneider (Bot. Zeit. 1853, p. 710, &c.; 1854, p. 214, &c.). Upon these soon appear cells, filled with green substance, perfectly resembling the gonidial cells of the full-grown thallus. The cultivation of the young plant never succeeded beyond this point.

† Ann. des Sc. nat. 3 sér. xv. p. 120 (1851).

‡ J. D. W. Bayrhoffer, Einig. über die Lichenen und deren Befruchtung. Bern, 1851.

§ J. P. Vaucher, Histoire des Conferves d'eau douce. Genève, 1803, p. 43 *et seq.*

|| *L. c.* p. 14 *et seq.* pl. 2 & 3.

Thus the matter rested for more than fifty years, until knowledge took the place of conjecture. Pringsheim* it was who made the matter clear by the direct observation of the act of fecundation in *Vaucheria sessilis*. While other phycologists believed in a conjugation of the horn with the sporange standing beside† it, and Karsten‡ thought that he discovered a process of fecundation by the emission from the horn of a cell containing formative matter (which he compared with the pollen-cell, as supposed to be efficient on Schleiden's former hypothesis), which united, together with its membrane, with a germ-sac-cell contained in the sporange, and thus became a productive (*entwicklungsfähig*) germ or spore,—Pringsheim saw the terminal cell of the horn open at its point and emit a great number of minute, bacillar corpuscles—spermatozoids, which slipped away in all directions with a rapid motion. Many of them crowded into the orifice already formed in the beak-like apex of the sporange by the pressure of its accumulated protoplasm—*into the micropyle of the sporange*, and appeared partly to penetrate into the protoplasm itself. Immediately upon this, the protoplasm became enveloped by a new cell-membrane, and thus appeared as a complete resting-spore, completely filling the sporange. The formation of the horn—the *antheridium*, as well as that of the sporange, takes place by a papilla-like bulging-out of the wall of the tubular cell of *Vaucheria*, such as happens in the ordinary ramification, and a subsequent separation of its cavity from that of the general filament of the Alga, by a septum. The sporange remains as a simple cell, until the time of the formation of the spore; the curved, tendril-like antheridium is divided by a cross-septum into two superposed cells before it is mature.

In May of last year I had an opportunity of making confirmatory observations on this important discovery of Pringsheim's, which at once throws a bright light over the essential nature of the fecundating process in the vegetable kingdom, and fills up a hiatus in the related observations on the higher Cryptogamia.

Specimens of *Vaucheria sessilis*, collected in a ditch at Jena, exhibited both perfectly ripe fruits and partly decomposed horns, and, besides these, all the earlier stages of development of the sporange and antheridia, back to the earliest nipple-like pro-

* N. Pringsheim, Ueber der Befruchtung, &c., der höheren Algen. Monatsbericht der K. Acad. d. Wiss. Berlin, 1855. (Abridged in Ann. Nat. Hist. 2 ser. xiv. p. 346, &c. Quarterly Journal of Microscop. Science, iv. p. 63.)

† *Vide* Nägeli, Neuerer Algensystem, &c. Zurich, 1847, p. 175. pl. 4. figs. 21 & 22; and A. Braun's doubts as to Nägeli's account in his 'Verjüngung,' &c. (Transl. in Ray Society, vol. 1851, p. 296.)

‡ H. Karsten, Der Fortpflanzung der *Conferva fontinalis*, L. Botan. Zeitung, 1852, p. 89. pl. 2.

jection on the wall of the main tube. It was not difficult to find, after a little search, some which gave signs that the act of fecundation might be immediately expected,—that is, sporanges in which the orifice for the entrance of the spermatozoids was already formed at the apex, while the neighbouring horn was still perfect. I isolated several of the filaments so developed, and carefully covered those which appeared ripest with a piece of thin glass, in order to trace their further development under the microscope. The pressure of the cover was even too much for the antheridia which were near bursting. They opened, and I saw the greater part of their mucous contents exude with a sudden jerk. A quantity of short spindle-shaped corpuscles escaped from this, and moved about in the water by means of cilia vibrating like a whip-lash (whether each corpuscle bore one or two—and, indeed, as it appeared to me in several, one at each end of the body—I could not make out with certainty). I saw but few, as compared with the total number, penetrate into the open beak of the sporange, and there perform the movement of crowding against the mass of protoplasm as described by Pringsheim. Whether any of them actually penetrated into this, I could not certainly ascertain. Pringsheim, indeed, has not directly observed the penetration of the spermatozoids into the mass of protoplasm; he rather concludes it, from the subsequent detection of a colourless corpuscle inside the new cell-membrane.

In the germination of the resting-spore of *Vaucheria*, the inmost layer of its membrane is directly developed into the thallus-filament*.

Pringsheim has demonstrated the existence of at least the *micropyles of the sporanges*, in which the resting-spores originate, in a number of other freshwater Algæ,—for example, in *Achlya prolifera*, where they exist in numbers probably equal to that of the spores formed in each sporange†; in *Œdogonium* and *Bulbochæte*. And his observations render it probable that the *microgonidia* first described by Alex. Braun‡, and shown to exist in various families of freshwater Algæ, which in *Bulbochæte* and *Œdogonium* attach themselves upon the sporangium or in its immediate neighbourhood§, and discharge their contents either immediately or after forming a few cells—are to be regarded as *antheridia*.

* Pringsheim, *l. c.* p. 12.

† Thuret represented them in the masterly drawings accompanying his "Memoir on the Zoospores of Algæ," but he regarded them as little lids. Ann. des Sc. nat. 3 sér. xiv. p. 231. pl. 20. fig. 11 (1850).

‡ Alex. Braun, 'Verjüngung' (Ray Soc. vol. 1851, p. 137).

§ As observed also by De Bary, and figured in his essay "On *Œdogonium* and *Bulbochæte*," Abhandl. der Senkenberg. Naturf. Gesellsch. i. pl. 3 & 4. (Frankfort-on-Maine, 1854.)

(*Supplementary note.*—Just before the printing of this essay, we received, through the kindness of the author, Pringsheim's second memoir on the fecundation and alternation of generations in the Algæ*. This contains a full confirmation of the conjecture in the preceding paragraph. Pringsheim saw developed in a portion of the species of *Œdogonium* and in *Bulbochæte*, in the end-cells of a structure (*male plant*) produced from a microgonidium (now called *androspore*, to distinguish it from all other, probably very diverse swarming bodies hitherto confounded together under the name of microgonidia)—in each a spermatozoid furnished with cilia, which, after it had been set free, completed the act of fecundation exactly in the same way as in *Vaucheria*. In a portion of the species of *Œdogonium* the spermatozoids are developed singly in determinate, successive cells of the *Œdogonium*-thread, which consists of only one row of cells. In this case, Pringsheim applies the name of *antheridium* to the whole sum of the cells forming spermatozoids.)

In *Achlya prolifera* the antheridia are perhaps represented by the branchlets, first described by Alex. Braun (also in *Coleochæte pulvinata*†), which apply themselves upon the sporangium, and penetrate into the orifices of this by means of lateral, papillary, projecting processes. In *Bulbochæte*, as also in *Coleochæte* and probably in *Œdogonium*, the subsequent development of the resting-spore is essentially different from that of *Vaucheria*. It does *not directly* produce the thallus of the plant, but *zoospores* (almost like the other zoospores of the same plant), by the germination of which is first produced the structure resembling the parent plant.

A similar condition, formation of *spores of a third kind*, according to Pringsheim, occurs sometimes in the resting-spore of *Achlya prolifera*‡, probably also in *Spirogyra jugalis*§; whether

* Monatsbericht der Berlin. Acad. 1856.

† Alex. Braun, *l. c.* (Ray Transl. 298).

‡ Pringsheim, Entwickl. der *Achlya prolifera*. Nova Acta A.C.L.C. xxiii. pt. 1. p. 427. pl. 47. fig. 17. *Vide* also Nägeli in Zeitschr. f. wiss. Botanik, von Schleiden and Nägeli, 3 & 4 Heft, p. 30, note (1846).

§ Flora, 1852, p. 479. (Ann. Nat. Hist. 2 ser. xi. p. 210 *et seq.*) The active spores here described by Pringsheim in *Spirogyra jugalis*, formed sometimes in conjugated cells, sometimes in unconjugated young filaments, probably occasionally also in the conjugation-body itself—which Nägeli was also acquainted with, and, since they did not appear capable of germination, compared with the 'swarming-cellules' (spermatozoids) of *Fucus* (Botan. Zeit. 1849, p. 578)—are identical with Itzigsohn's '*spermatosphæria*' (mother-cells of spermatozoa) of *Spirogyra arcta*, Kütz.; the cilia of these spores doubtless constitute the little heads or tails of the discharged spiral animalcules which Itzigsohn described. (*Vide* the letter of this author on this subject to Tulasne, Ann. des Sc. nat. 3 sér. xvii. p. 150 (1852), and his figures in 'Hedwigia,' 1852, No. 2. pl. 1, and in Botan. Zeitung,' 1853,

the quaternary division of the spores of *Mesocarpus, Staurocarpus,* and *Tyndaridea,* observed by Thwaites*, is referable here, must be shown by further observation. Parallel to this stand the conditions observed in the zoospores. Pringsheim has observed their division in *Achlya*†; and in *Œdogonium vesicatum,* Link, the same observer saw the contents of a germinating zoospore which had come to rest, transformed into a number of small, active spores, which again germinated‡.

Similar sexual conditions are rendered probable in the Palmellaceæ, by the discovery of resting, red spores (together with the zoospores).

Cohn has not only likewise confirmed the observation of Pringsheim on *Vaucheria,* but at the same time brought forward a new example of sexual reproduction in the Algæ, and in a plant widely differing from *Vaucheria,* namely *Sphæroplea annulina*§. The spermatozoids, externally resembling the microgonidia of other Algæ||, which are developed in separate cells (*antheridia*) and are discharged from these by a previously-formed orifice, here fecundate still membraneless spores, formed by the division of the cell-contents, in other cells (sporangia), to which they make their way through minute orifices. Cohn does not consider that observations justify his assuming a direct penetration of the spermatozoids into the primordial spore-cell; it rather seemed to him as if they attached themselves on the outside of the spore, and were finally converted into mucilaginous globules. The further development of the fecundated spore is essentially the same as in *Bulbochæte.*

We have likewise recently received a satisfactory key to the import of the *conjugation of the Algæ.* Areschoug's¶ observations on this in the Zygnemeæ lead him to the conclusion, that the spores now and then observed in cells which have not con-

p. 201. pl. 5.) Cohn regards the structures in question, not as reproductive bodies, but foreign structures belonging to the domain of fermentation-phænomena (Unters. üb. Mikroskop. Alg. u. Pilze. Nova Acta A. C. L. C. xxiv. pt. 1. p. 160.) [This is decidedly erroneous.—A. H.]

* *Vide* Botan. Zeitung, 1846, p. 498.

† *Flora,* 1852, p. 484, note. ‡ *Ibid.* 1852, p. 482.

§ Ferd. Cohn, Ueb. Entwickl. u. Fortpflanzung der *Sphæroplea annulina.* Monatsb. Berl. Acad. May 1855. (Transl. in Ann. Nat. Hist. 2 ser. xviii. p. 81.)

|| Meyen (Pflanzenphys. iii. p. 446) asserts that he often observed in very various Confervæ, about the time when the spores are formed, an innumerable quantity of small, spirally curled, and spirally or undulatingly moving animalcules (*spirilla*), and he represents these in *Sphæroplea annulina,* in plate 10. fig. 17; his drawing, however, agrees so little with Cohn's description of the spermatozoids of these Algæ, that it is difficult to suppose that Meyen really saw the same things.

¶ *Vide* 'Flora,' 1855, p. 675 *et seq.*

jugated, have not really the import of spores, but represent only the condition of cell-contents metamorphosed into a daughter-cell (?) just before conjugation; and the same of those cases in which a spore appeared to be contained in each of the conjugated cells. This author, in the last case, saw one of the supposed spores send out a long, tubular process through the conjugation-canal which pierced into the other pseudo-spore (in light-coloured, longish places lying transversely as regards the long axis of the conjugation-cell); its remaining portion soon passed by degrees through the canal, and penetrated into the interior of the other spore. The real spore was produced out of the pseudo-spores united in this way, and in a few days appeared in the same form as the resting-spores of the other joints. Further, the same observer saw all the stages of a case in which two supposed spores occurred in one conjugation-cell, arising from the tubular prolongation of the travelling pseudo-spore missing the above-mentioned spot in the other, and its penetration being thus frustrated; in this case no formation of a spore followed,—the two pseudo-spores, lying side by side, were dissolved without undergoing any further change.

The direct production of a plant resembling the parent-filament, from the spore produced through conjugation (of *Spirogyræ*), was observed by Vaucher*, and has been recently confirmed by Alex. Braun† and Pringsheim‡.

In the Fucoideæ, J. Ag., the presence of antheridia was first demonstrated by Thuret, and this in the section Fucaceæ. They here consist of ovate cells, seated on the hairs of conceptacles sometimes special and sometimes containing also sporanges, and they are filled with zoospore-like spermatozoids (antherozoids, Thuret). Lyngbye, Montagne, J. Agardh, Kützing, and other inquirers had already observed these, without having arrived at any clear conception of their import: by most, even by Nägeli§, Mettenius‖, and Al. Braun¶, they were taken for true zoospores, although no germination had been observed. Reaumur** had first announced the existence of male organs in *Fucus*, taking for such the filaments in the *cryptostomata* of Kützing.

First in connexion with Decaisne††, and next in his essay on

* Conferves d'eau douce, p. 47. pl. 4, 5 & 6.

† Verjüngung, &c. (Ray Transl. p. 135.)

‡ Pringsheim, Algol. Meth. Flora, 1852, p. 465. (Transl. in Ann. Nat. Hist. 2 ser. xi. p. 210, &c.)

§ Bot. Zeit. 1849, p. 578.

‖ Mettenius, Beiträge z. Botanik. Heidelb. 1850, p. 34.

¶ Verjüngung, &c. p. 152. (Ray Soc. transl. 1851, p. 142.)

** Historia Fucorum. Petrop. 1768.

†† Decaisne et Thuret, Ann. des Sc. nat. 3 sér. iii. p. 5 *et seq.* (1845).

the antheridia of the Cryptogamia*, Thuret assumed the active 2-ciliated corpuscles contained in the above-mentioned cells to be *spermatozoa,* on account of their not germinating; more recently†, he has given proof of the correctness of his hypothesis by experiments on dioecious species of *Fucus,* showing that where these bodies are excluded, the spores remain incapable of germination, *i. e.* unfecundated. According to his account, the spores (sporules of authors) are formed in eights, fours, twos, or only one, in the unicellular sporanges, which have a smaller cell forming a pedicle to attach them to the wall of the conceptacle. These spores emerge from the sporange as primordial cells, as yet unenclosed by a proper membrane, but surrounded by a common envelope (and thus hitherto regarded by authors as single 8- &c. parted spores, octospores, &c.), from which they are immediately set quite free, and come in contact with the spermatozoa. The author could not detect a material penetration of the spermatozoa into the spore-mass. Soon after fecundation‡ the spore becomes clothed by a cell-membrane, and then is developed into the young plant.

Pringsheim§ confirmed Thuret's statements. The only difference is, that Pringsheim thinks the spermatozoids actually penetrate into the membraneless spore-mass, and are immediately enclosed by the new cell-membranes. He was led to this opinion by observing a number of small red-brown nuclei inside the spore-membrane, which were not present before the fecundation, and appeared to him to be the remains of the spermatozoids, which are furnished with a red nucleus.

With regard to the other sections of the Fucoideæ, spermatozoids have been described by Thuret‖ in *Cutleria,* by Pringsheim in *Sphacelaria* and *Cladostephus*¶. The structure of the antheridia is different in these plants.

In the Florideæ peculiar organs have likewise been long known, which the first observers, although without sufficient reasons, explained as antheridia. This was the case with C. Agardh. Lyngbye regarded them as an animal structure; J. Agardh as a hypertrophic metamorphosis of the ordinary organs of propagation; Kützing** applied to them the name of 'spermatoidia,' considering them as seed-like accessory struc-

* Ann. des Sc. nat. 3 sér. xvi. p. 5 (1851).

† *Ibid.* 4 sér. ii. p. 197 (1854).

‡ Thuret, Mémoires de la Soc. Imp. de Cherbourg, v. April 1857.

§ Pringsheim, Ueb. d. Befruchtung u. Keimung der Algen. Berlin, 1855, p. 12 *et seq.* (Annals, 2 ser. xiv. *l. c.*)

‖ Ann. des Sc. nat. 3 sér. p. 12 (1851).

¶ Ueb. Befrucht. der Algen. Berlin, 1855, pp. 21, 23.

** Phycologia generalis, pp. 107–109 (1843).

tures, the development of which into new individuals had not yet been observed.

They ordinarily occur upon distinct individuals, and occupy upon them the same places as the fruits on the fertile plants. Their essential portion consists of numerous small round cellules, which are sometimes grouped, without any envelope, upon special organs, or definite regions of the frond, but sometimes enclosed by a common cuticle. These cellules were compared by Nägeli* with the spermatic cellules of the antheridia of Mosses, and he believed that he detected in them a spiral filament lying upon the wall. Derbès and Solier† also believe that each cellule contains an antherozoid, with a filiform appendage as an organ of motion.

Thuret‡ demonstrated with certainty the absence of this structure. According to him each antheridial cellule contains a hyaline, spherical or longish corpuscle, with somewhat granular contents (*antherozoid*), which is expelled with a slow movement from the cell, but then comes to perfect rest. Mettenius§ could detect no movement of these corpuscles, which he regarded as cells formed out of the entire contents of the antheridial cells. He applied to them the name of 'seminal cellules' (*Samenzellchen*) but declared himself inclined to regard them as spores which do not possess the power of germination. Pringsheim‖, who calls them simply antheridium-cells, compares the statements of Thuret and Mettenius; the absence of movement is insufficient, in the face of the agreement of their structure with that of the spermatozoids of Fucaceæ and of *Sphacelaria*, to permit his asserting them not to be the real spermatozoids of the Florideæ.

At the same time, this author concludes, from his observations on the germination of the tetraspores and capsule-spores of *Ceramium*, that the former, which produce immediately a new plant resembling the parent, only officiate like buds, for asexual propagation; but that the capsule-spores are either themselves the true female sexual organs of the Florideæ (in those namely where the capsule-fruit has a canal penetrating into its interior), or (in those with a closed fruit, as *Ceramium*) that the structure produced from them in germination, unlike in appearance to the parent-frond, represents a kind of prothallium, which in some manner takes on the female sexual function.

* Nägeli, Neuer. Algensystem. Zurich, 1847, p. 190. pl. 6 & 7; also in Zeitschr. f. wiss. Bot. 3 & 4 Heft, p. 224 (Zurich, 1846), and Botan. Zeit. 1849, p. 569.

† Derbès et Solier, Org. reprod. des Algues. Ann. des Sc. nat. 3 sér. xiv. p. 275 *et seq.* (1851).

‡ Rech. sur les Antherid. &c. Ann. des Sc. nat. 3 sér. xvi. p. 14 (1851).

§ Beitr. zur Botanik, pp. 36, 39, 42.

‖ Ueb. Befrucht. der Alg. p. 16.

Characeæ.—These plants, hitherto destitute of a fixed home in Systematic Botany, we treat in connexion with their relatives the other Algæ, from which they have never been separated but with reluctance or by violence, and among which they will doubtless for the future occupy their right place, namely the uppermost.

The two kinds of organs of fructification are so conspicuous in these plants, that they were known in the earliest days of observation. The views of the older botanists were in tolerable agreement as to their sexual nature, although direct observations on the act of fecundation itself were and are still wanting. Most recent writers preferred, and justly, to withhold for the time any opinion of the import of the 'globules' (antheridia).

Linnæus, from the resemblance in external structure and the order of development, regarded the red 'globules' of *Chara* as anthers, the spores with their 5-celled envelope (sporange) as the pistil; and ultimately transferred these plants, which he had at first placed among his Cryptogamia*, into the Monœcia Monandria†.

Hedwig‡, in whose works we find figures executed with his usual accuracy, so far as the means of observation then accessible permitted, regarded the red granular contents of the oval cells which serve as the peduncle of the triangular external cells of the globules (and upon which appeared to him to depend the red colour of the external cells), as the fecundating matter,—the granular contents of the spore, exclusive of the starch-granules, as the proper seeds.

Vaucher§, Kaulfuss‖, Bischoff¶, C. H. Schultz**, and K. Müller†† each observed the entire development of plants resembling the mother-plant from the spores. In this operation the spore (*nucule*) ordinarily first loses its cellular covering (*sporangium*), the outer coat of the spore opens at the upper end of the spore, and the inner cell expands into the first cell of the young plant.

Fritsche‡‡ furnished an exact description and representation of the globules (antheridia) and the spiral filaments contained in

* Genera Plant. Ed. 6. Holm. 1764, p. 567.

† Systema Naturæ. Ed. 12. Holm. 1767, ii. p. 613.

‡ Theor. Generat. et Fructif. Plant. Crypt. &c. Petrop. 1784, p. 125. pl. 22, 33.

§ Mém. sur les Charaignes. Mémoires de la Soc. de Phys. et d'Hist. nat. de Genève, i. pt. 1. p. 168 (1821).

‖ Erfahrung. über das Keimen der Charen. Leipsic, 1825.

¶ G. W. Bischoff, Krypt. Gewächse. Nuremb. 1828, p. 9.

** Natur der lebenden Pflanze, B. ii.

†† K. Müller, Zur Entwickl. der Charen. Botan. Zeit. 1845. (Transl. in Ann. Nat. Hist. xvii. p. 254.)

‡‡ Fritsche, Ueber den Pollen. Petersburg, 1837, p. 6–19. pl. 1 & 2.

the confervoid rows of internal cells (pollen-cells, Fritsche). The Infusorium-like movement of these spiral filaments after their escape from the cells, was first observed by Bischoff*. Meyen† called them spermatozoids; in agreement with his statement, J. C. Varley‡ (1834) had already seen and figured a cilium on them, which Meyen himself copied§. Thuret‖ and Amici¶ showed that each spiral thread possessed two cilia. Thuret** believes even that he has detected the opening in the cells through which the spiral filaments escape, ordinarily with the unciliated end first. According to the concurrent testimony of all observers††, the spiral bodies are developed from (in ?) the nuclei, which, however, are not so sharply defined, but more irregularly shaped than usual. They are not formed simultaneously in a whole row of cells, but, according to Thuret, first in the cells of the apex, subsequently in those of the base of a filament;—according to Mettenius, in the contrary order.

Although we possess no direct observation on the process of fecundation in the *Charæ*, when we look at the certain explanations which we have lately obtained as to the import of active spiral filaments in the vegetable kingdom, and at the above-described mode of development of the young plants of *Chara* from the spore,—we may with safety suppose that the fecundating process takes place here before the complete development of the spore, and that to produce this the spermatozoids penetrate into the young sporange. In this hypothesis we are strengthened by the circumstance that the cells of the sporange are not completely closed up over the spore-cell in the earliest stage of its growth, but leave between them an open canal; the ripening of the antheridia, their dehiscence, and the emission of the spermatozoids taking place at this epoch; further, that in

* Kryptog. Gewächse, p. 13, note.

† J. F. Meyen, Pflanzenphys. ii. pp. 206, 217.

‡ Improvements on the Vial Microscope. Trans. Soc. of Arts, &c. London, vol. i.

§ Pflanzenphysiol. iii. pl. 12. figs. 22–28, and p. 222.

‖ Thuret, Note sur l'Anthère du *Chara*, &c. Ann. des Sc. nat. 2 sér. xiv. (1840).

¶ Flora, 1844, B. ii. p. 516.

** *Loc. supr. cit.* pl. 6. fig. 21.

†† See, in particular, Mettenius, Beiträge zur Entwick. der bewegl. Spiralfas. von *Chara hispida*. Bot. Zeit. 1845, p. 17. pl. 1.

Nägeli, Zeitschr. f. wiss. Botanik, Heft 1. p. 55 (1844); Heft 3 & 4. p. 105 (1846), where he calls the nuclei 'seminal utricles.'

Thuret, Sur les Antheridies des Cryptog. Ann. des Sc. nat. 3 sér. xvi. p. 21 (1851).

Schacht, Pflanzenzelle, p. 113 (Berlin, 1852).

(Alex. Braun, Monatsb. Berlin Acad. Jan. 1853. Ann. Nat. Hist. 2 ser. xii. p. 297.)

those species in which the spores do not ripen until late in the autumn, the germination does not take place until the following spring, and occurs therefore at a time when none of the previous year's spermatozoids remain and no new ones are yet developed.

[To be continued.]

XXIV.—*On* Rissoa pulcherrima. By William Clark, Esq.

To the Editors of the Annals of Natural History.

Norfolk Crescent, Bath, 14th Sept. 1857.

Gentlemen,

My friend Mr. Barlee, to whom all that are interested in malacological pursuits are under the greatest obligations, has just favoured me, from Guernsey, with many lively specimens of the *Rissoa pulcherrima* of recent authors, which has been constituted a species, solely, I believe, from conchological indices. I have therefore thought that some of your readers would be glad to have an account of the external organs of this, if it be so, undescribed animal.

Rissoa pulcherrima, Forbes and Hanley.

Shell spiral, ovately conical, pale yellowish-white, of $3\frac{1}{2}$–$4\frac{1}{2}$ well-rounded volutions divided by a rather deep suture, and marked with 2–4 rows of distinct, palish rufous spots, which in other words are lines running from base to point, that are variously interrupted, so as to form well-separated, subquadrate, minute areas. The aperture is suboval, usually thin at the outer margin, with little or no umbilical fissure. Axis $\frac{1}{15}$–$\frac{1}{20}$, diameter $\frac{1}{33}$–$\frac{1}{43}$ of an inch.

Animal.—Ground-colour white, shot with the minutest snowy flakes and points, and blotched with dark smoke patches and lines, as well as with more or less yellow or sulphur-coloured suffusions on particular parts of the body. Mantle entire; but I did not detect the pendent filament from the aperture, which I have often mentioned as visible in the *Rissoæ*, and which is perhaps the generative organ.

Rostrum moderately long, above longitudinally cloven or bilobed; buccal disk below having the usual vertical fissure, from which the animal frequently protrudes the white corneous jaws and masticatory processes; it is tinged with yellow hues, above and below, of various intensity and extent.

The tentacula are long, slender and flat, rounded at the tips, and horizontally clothed with fine setæ; the eyes are large,